

PROCEEDINGS OF LEARNED SOCIETIES.

ROYAL SOCIETY.

January 16, 1862.—Dr. William Allen Miller, Treasurer and Vice-President, in the Chair.

“On the Development of Striped Muscular Fibre in Man, Mammalia, and Birds.” By J. Lockhart Clarke, F.R.S.

In the domestic fowl, until the beginning of the fifth day of incubation, the so-called voluntary muscular tissue consists only of a crowded multitude of free nuclei imbedded in a finely granular blastema; the nuclei are round, oval, pyriform, and somewhat angular, with granular contents. On the fifth and sixth days of incubation, fibres become superadded under two forms,—1st, as processes extending from the ends, or from the sides of nuclei; 2nd, as narrow bands, either uniformly delicate and pale, or bordered by darker outlines, and containing nuclei at variable intervals. They are most numerous near the surface of the layer, and probably belong, at least partly, to the muscular layer of the skin. In every case their first stage of development is conducted on one general plan, which consists in the fibrillation of the blastema along the sides of nuclei, to which the fibrillæ so formed become adherent. Sometimes these fibrillæ or lateral fibres enclose a single nucleus with conical processes of blastema, so that the object occasionally presents some resemblance to a fusiform nucleated cell. More frequently, however, they enclose a linear series of nuclei at variable distances from each other, but cemented together by blastema, which sometimes assumes around each a more or less definite shape. In the formation of the paler fibres, however, a series of neighbouring nuclei may sometimes be seen first to collect round themselves granular masses of a more or less fusiform appearance, and then to coalesce with each other, in an oblique or alternately imbricate way. Sometimes a series of the nuclei themselves overlies each other in an imbricate form like a number of coins, and are cemented together by a common layer of blastema.

In the early part of the seventh day of incubation, numerous fibres of a much larger and more striking description suddenly make their appearance in the nucleated blastema. They originate, however, on the same general plan as the others, in a fibrillation of the blastema between, or along the sides of, a variable number of nuclei; but the process goes on to form aggregate masses of a much larger kind, and of a more or less oval, fusiform, or cylindrical shape, in which the nuclei are ultimately enclosed. Some of these bodies have a very striking resemblance to organic muscular-fibre-cells, which, according to my own opportunities of observation, are developed on the same general plan, that is, by the formation of sarcous substance, first, in the shape of fibres or lateral bands along the sides of a nucleus more or less encrusted with blastema, so that the *organic* muscular-fibre-cell would appear to represent an early stage in the development of the *striped* muscular fibre.

As incubation advances, the fibres acquire a tubular investment of the contractile or sarcous substance, which gradually increases in thickness or depth, and appears on each side as a band of corresponding breadth. As they grow in length, they also contract in diameter, and become of uniform structure throughout; while their nuclei rise nearer to the surface, and assume a more oval form. At this period the marks of striation, either longitudinal or transverse, are only faint and occasional.

By the fourteenth day of incubation, the entire substance of the fibres separates into longitudinal fibrillæ, which in turn become shortly resolved into particles or sarcous elements. After this the fibres continue to grow in thickness by the addition, to their surfaces, of new fibrillæ, which, as usual, are formed around nuclei encrusted with blastema cementing them, in such cases, to the original fibre.

In mammalia, although there are some particular but unimportant differences in the development of muscular fibre, the general plan is the same as in birds. The nuclei—at least in the ox, sheep, and pig—are larger, and have more distinct cell-walls or enveloping membranes. The fibres of the sheep or pig first make their appearance, in the fœtus of from half to three-quarters of an inch in length, as thick and nearly parallel threads lying amongst a densely crowded mass of free nuclei. When isolated, these fibres are seen to be attached to one or more of the nuclei by a variable quantity of blastema. Sometimes a single nucleus with conical processes of delicate granular substance is first enclosed by fine fibrillæ or lateral bands, which present somewhat the appearance of a *cell-wall*, so that the object has a certain resemblance to a nucleated fusiform cell with a fibre originating from one of its extremities. Sometimes several nuclei are cemented in a group around a fibre, and become subsequently covered by other fibres of the same kind; and sometimes they lie in linear series, either at some distance apart, or overlying each other to a certain extent like a series of coins. The lateral bands or fibres enclosing the nuclei extend around them as a tubular investment, which grows in thickness from without, but not always uniformly on all sides. In the process of longitudinal growth, the nuclei multiply by subdivision, become generally more oval, and approach nearer to the surface of the fibre, which at the same time contracts in diameter. The subsequent changes they pass through are nearly similar to those which occur in the chick.

In man the development of muscular fibre proceeds on the same general plan as in birds and mammalia, but differs from that of both in certain unimportant particulars. In the early stages there is no distinct appearance of those oval, cylindrical, and irregular masses observable in the chick on the seventh day of incubation and in the mammal at a corresponding period. In this respect there is a greater resemblance between the two latter classes than between man and either. In the human fœtus, from about half to three-quarters of an inch in length, the first stage of development may be seen to commence by the formation of fine lateral bands or fibrillæ along one or both sides of one nucleus or more. When, however, there are more nuclei than one enclosed by the same lateral bands, they are always

disposed in linear succession, with their longer axes in the direction of the fibre, and never occur in irregular groups, as is sometimes the case both in birds and mammals, in which, consequently, the same kind of fibres are often broader at first. Thus formed, they lie side by side in bundles of different sizes, to which new fibres or new fibrillæ are being continually added by a renewed process of development. Every fibre is the rudiment of several fibrillæ. At this period each lateral band constitutes a single fibrilla, which is often resolved into sarcous elements of great distinctness and beauty, while new and similar fibrillæ are developed along its sides in the way already explained. The subsequent series of changes do not differ materially from those that occur in the inferior classes.

It is evident that this description of the development of muscular fibre is entirely opposed to the cellular theory of Schwann; while it agrees in some points with that of Lebert (*Annales des Scien. Nat.* 1849-50), but more with that of Savory (*Phil. Trans.* 1855). In no instance have I found that nucleated *cells*, properly so called, are concerned in the office of development; for the finely granular blastema attached to the nuclei, although it frequently assumes the shape of a fusiform *cell*, is not invested with a *cell-wall*, in the proper sense of the word. Such an envelope, however, is sometimes simulated by the investing sarcous substance or fine lateral fibrillæ when they are first laid down on the sides of the fusiform mass and meet each other at each extremity to form a single fibre or process. Indeed, according to my own observations, as already remarked, this is precisely the mode in which the *organic* muscular-fibre-cell is developed; so that the *striped* muscular fibre, instead of being the *product* of nucleated *cells*, would appear to be itself, at first, an instance or mode of cell-formation, which finds its prototype in the *organic* muscular fibre-cell, and in which the *cell-wall* is substituted and represented by the investing sarcous substance.

January 23, 1862.—Major-General Sabine, R.A., President,
in the Chair.

“Additional Observations and Experiments on the Influence of Physical Agents in the Development of the Tadpole and the Frog.”
By John Higginbottom, Esq., F.R.S.

In a former paper “On the Influence of Physical Agents on the development of the Tadpole of the Triton and the Frog,” which the Royal Society honoured with a place in the *Philosophical Transactions* for 1850, experiments were detailed to prove that the ovum of the frog (the *Rana temporaria*) underwent its metamorphosis in the absence of light, contrary to the experiments of Dr. W. F. Edwards of Paris, related in his work ‘*On the Influence of Physical Agents on Life.*’

My most satisfactory experiment was made in a rock cellar 30 feet deep, where no solar light ever entered; the mean temperature of the cellar was 51° Fahr.,—I believe, the lowest temperature at which the transformation could be effected.

The ova of the frog, just deposited, were placed in the cellar on

the 11th of March, and on the 31st of October the first was fully developed in the form of a frog; while other ova deposited on the same day, which were placed in a shady part of a room at 60° Fahr. and covered with several folds of black calico, were fully developed on May 22nd, twenty-three weeks earlier than those in the cellar.

The experiment proved that the development of the frog depended upon the temperature, and not upon the presence of light. I found by other experiments that those in the light, and those deprived of light, were equally developed if placed at the same temperature. I observed that an excess of light retarded the development.

1. *On the Influence of Light on the Ovum.*

My former experiments not being parallel with those of Dr. Edwards, I was desirous of following his steps. Dr. Edwards says, in his work above referred to, Part iv. chapter 15, 'On the Influence of Light upon the Development of the Body,' "This process, previous to birth, is generally carried on in the dark; there are, however, animals whose impregnated eggs are hatched, notwithstanding their exposure to the rays of the sun. Of this number are the Batrachians. I wished to determine what influence light independent of heat might exert upon this kind of development. With this view I placed some spawn of the frog in water in a vessel which was rendered impermeable to light by dark paper. The other vessel was transparent; they were exposed to the same degree of temperature, but the transparent vessel received the rays of the sun. The eggs exposed to the light were developed in succession; of those in the dark, none did well; in some, however, I remarked unequivocal indications of the transformation of the embryo."

Dr. Edwards does not mention the depth of water in the vessel in which he put the spawn of the frog, which he "rendered impermeable to light." If it were a few inches in depth, it would materially prevent the transformation of the embryo.

I commenced my experiment in a pool which had been the habitat of frogs (the *Rana temporaria*) for several years.

Experiment 1st.—I put a quantity of spawn, just deposited, into a box perforated with small holes, so as to admit a free current of water through it, and placed it about 3 feet below the surface of the water; all the ova perished.

The next experiments were made in an aquarium 20 inches deep, containing seventeen gallons of water at 60° Fahr.

Experiment 2nd.—A quantity of spawn was put into the water, which fell to the bottom of the aquarium; the spawn when first deposited by the frog, is specifically heavier than the water*. The

* It is found that the frog usually deposits her spawn in shallow water, often close to the edge of a pool favourable to its development; at first it is very adhesive, and adheres firmly to the ground or weeds where it is deposited. The same condition may be observed when the animal deposits her spawn in an earthenware vessel. In this neighbourhood the deposition begins about the end of February or the first days of March, and continues fourteen or sixteen days, when the frogs quit the water.

ova enlarged as usual, but did not arrive satisfactorily through the branchial state; most of the ova appeared to undergo no change whatever.

Experiment 3rd.—Some spawn was placed 8 inches below the surface of the water; but none of the ova passed through the branchial state.

Experiment 4th.—A quantity of spawn was placed on rock work near the surface of the water. Nearly all the ova passed satisfactorily through the branchial state to the formation of tadpoles; each of the experiments was made at the same time and at the same temperature.

Experiment 5th.—A quantity of spawn was put into two round shallow dishes, each containing two pints of water, which were placed on the stand of the aquarium at the same time as in the former experiments; nearly all did well; and during the full branchial or fish-like state, great numbers of the embryos had placed themselves close to the margin of the water, forming a dark circle, with their branchiæ nearly exposed to the atmospheric air. They do not appear to feed during this period on the jelly—their first food; atmospheric respiration seems more needful than food for their existence for several days during their full branchial state*.

There are two distinct metamorphoses from the ovum to the full development of the frog: the first from the branchial or fish-like state to that of the tadpole; the second from the tadpole to that of a frog,—the first requiring for its existence a close approximation to the atmospheric air, the second requiring full atmospheric respiration, to which I shall hereafter refer.

The branchial state continues about nine days, from the first bud-dings of the branchiæ to their absorption. About the seventh day the branchiæ are absorbed on the *right side*, indeed so quickly that I have observed that scores have lost them during one night, whilst the branchiæ on the left side have apparently been perfect; but these in their turn become absorbed during the next day; the respiration of this newly formed tadpole now depends on the internal gills and cutaneous surface. The gill-opening for the passage of water is very apparent on the left side, but there is none on the right.

2. *On the Influence of Light on the Tadpole.*

The experiments of Dr. Edwards indicate that a decided influence is exerted by light upon the metamorphosis of Batrachians, since, according to his statement, when tadpoles which had arrived at nearly their full growth were secluded from the influence of light,

* The ova of the toad appear to be less tenacious of life than those of the frog. I have observed, when they are placed 4 or 5 inches below the surface of the water, they all die; but they live when the long jelly lines in which the ova are enclosed are floated on weeds, or on a network of sticks on the surface of the water. In my note-book on the tadpole of the toad in 1849, I found that after the gelatinous lines began to break up on the surface of the water, and the ova to separate from them, a number of the eggs undergoing the metamorphosis adhered to the sticks and weed, but those falling to the bottom of the vessel perished.

but supported with aerated water and food, they attained an extraordinary size, without undergoing any metamorphosis. The following is Dr. Edwards's experiment:—"I procured a tin box, divided into twelve compartments, each of which was numbered and pierced with holes so that the water might readily pass through the box. A tadpole (which had been previously weighed) was put into each compartment, and the box was then placed in the River Seine, some feet below the surface. A large number were at the same time put into an earthen-ware vessel, containing about four gallons of Seine water, which was changed every day; these tadpoles were at liberty to rise to the surface and respire air, and they soon went through their metamorphosis. Of the twelve placed in the box under water, ten preserved their form without any progress in their transformation, although some had doubled or trebled their weight. It should be observed that at the time when the experiment was begun, the tadpoles had attained the size at which the change is about to take place. Two only were transformed, and these very much later than those which, in the earthen vessel, had the liberty of respiration in air." Dr. Edwards concludes that the presence of solar light favours the development of form.

The situation in which Dr. Edwards placed the tadpoles, "some feet below the surface of the river" in his experiment, would inevitably prove unsuccessful in the full development of the frog. I have always found the transformation, both of the triton and of the frog, equal in the same temperature, both in the light and in the absence of light, if placed in shallow water; but during their metamorphosis they must be allowed to rise to the surface of the water to obtain air, or they become asphyxiated. I therefore placed stones in the vessel, and allowed them to leave the water for the purpose of atmospheric respiration.

The metamorphosis of the tadpole, when at its *full* growth, requires about fourteen days to bring it to the condition of a frog. About the termination of that period, the diminution of the body is so great, and also the absorption of the expanded caudal extremity is such, as to diminish cutaneous respiration. Respiration by the lungs becomes absolutely necessary to prevent the animal from becoming asphyxiated, which would be the case if it remained in the water—requiring then not an aquatic, but an atmospheric medium of respiration. It may be observed that after the tail is partially absorbed, leaving only a portion of the solid part, the asphyxiated state has commenced; the little animal, with open mouth, gasps for breath: but if removed into atmospheric air, the mouth is directly closed, and respiration is effected through the nostrils with perfect freedom; the animal is restored directly, jumps about and is lively.

3. On the Influence of the absence of Light on the Tadpole and on the Frog.

This time I commenced my experiments in three rock cellars, formerly only in one.

The cellars in Nottingham, cut out of solid rock, are most favourable for experiment; no solar light ever enters, and they are not subject to any great change of temperature. The deepest cellar is 30 feet deep, the mean temperature 51° Fahr.; the middle cellar is 18 feet deep, its mean temperature 53° Fahr.; the uppermost cellar 9 feet deep, mean temperature 56° Fahr.

June 11th. In each cellar I placed a shallow glazed earthenware vessel, containing two pints of water, with grass for chlorophyll for food, changing the water every second day. In each vessel I put twenty tadpoles, approaching the period of their metamorphosis, following the example of Dr. Edwards,—a much easier method than commencing with the spawn.

In the uppermost cellar ten were fully developed in the form of a frog on the 8th of September, and were on the stones, having left the water.

In the middle cellar ten were fully developed on the 22nd of September.

In the lowest cellar eight only had left the water, being fully developed on the 20th of October.

In the following year, July 1st, I made a similar experiment in the same cellars, three weeks later. The tadpoles were of a large size. I obtained the same result—the full development of the frog in the absence of light; but in this experiment I had another object in view, that of observing the growth and obtaining the exact weight of the tadpoles before, during, and after their metamorphosis into a frog.

Dr. Edwards said that in his experiment “the tadpoles attained an extraordinary size, doubling or trebling their usual full weight;” but he unfortunately does not mention any particular weight, or how long the tadpoles were preserved alive; in fact there is nothing definite.

During my several years of experiments I did not observe any remarkable increase of weight or size as mentioned by Dr. Edwards, although my first experiment was from the ovum to the full development of the frog, and the two last when the tadpoles were approaching the period of their development.

In my first experiment on the ovum, I never obtained a tadpole more than 8 grains in weight in the absence of light; but I found in a pool in the neighbourhood a number of tadpoles, some between 11 and 15 grains in weight; seven of them weighed 15 grains each. Of these large tadpoles I took twenty for my experiment, weighing altogether 264 grains, and averaging about 13 grains each. After their transformation the frogs weighed 93 grains, averaging about $4\frac{1}{2}$ grains each,—those of 15 grains in the tadpole state only weighing 5 grains as frogs, having lost two-thirds of their weight during their metamorphosis.

Subsequent experiments have been in accordance with the above.